

The Transpinnor: An Active Spin-Based Device*
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Integrated Magnetoelectronics

Abstract We report the operation at room temperature of an all-metal, active device based on electron spin, which we call the transpinnor. A transpinnor is a bridge of four electrically connected GMR (giant magnetoresistive) films whose resistance is controlled by the magnetic field from the current in one or more input striplines electrically isolated from the GMR films. The GMR elements are also connected to power terminals. When the transpinnor is resistively balanced its output remains zero even with power applied to it. A current in an input stripline unbalances the bridge and produces an output that depends on the power current. Transpinnors can be used as selection-matrix elements for magnetic memories, for logic elements of all kinds (e.g., AND, OR, XOR, NAND, NOT), for amplifiers, differential amplifiers, and magnetometers. Experimental results on integrated transpinnors will be presented, demonstrating its utility for logic, analog circuits, and amplification. We have also simulated the function and performance of various small-scale-integration (SSI) logic elements, based on measured GMR film properties. The aim was to verify functionality for a representative set of the SSI elements and to characterize all properties needed to design systems. Simulation results established that transpinnor logic gates are suitable as building blocks in large systems. The all-metal aspect of the transpinnor is unique. Unlike the mixed-technology systems that implement spin-based logic using both semiconductors and ferromagnets, transpinnor-based circuits are fabricated using only metal depositions on a monolithic chip; mixed technology requires fabricating semiconductor and magnetic elements on the same chip. All-metal devices have significant design, performance, manufacturing, and cost advantages over mixed ferromagnetic/semiconductor systems: nonvolatility, higher system performance, low system power, low system costs; the number of masking steps in all-metal magnetic-RAM processing is about one-third that in its mixed-technology counterpart. Transpinnors have been used to design a number of different all-metal logic gates and circuits, as well as amplifiers and selection circuitry for a 1 Mbit all-metal (support circuitry as well as memory array) magnetic RAM presently being fabricated.

* Work supported in part by the U.S. Department of Energy; and the Department of the Air Force, AF Research Laboratory

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